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DEVELOPMENT OF A CONTINUOUS, HARD-ANODIZED ALUMINUM SURFACE

Frank L. Harris, et al

Army Mobility Equipment Research and Development Center
Fort Belvoir, Virginia

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by

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DEVELOPMENT OF A CONTINUOUS, HARD-ANODIZED ALUMINUM SURFACE

Task 1T062105A328 03

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Prepared by

Frank L. Harris and Sidney Levine
Materials Research Support Division
Military Technology Laboratory

SUMMARY

A method is described for minimizing the effects of the discontinuities inherent in hard-anodized coatings on aluminum by the introduction of a secondary anodic film. Photomicrographs show the location of the secondary coating beneath the original, hard-anodized finish. Data are presented which indicate that the method described has no ill effect on the original abrasion resistance and that the continuity of the coating is significantly increased.

FOREWORD

Authority for the investigation described herein is contained in Task 1T062105A328 03.

The work was accomplished by Frank L. Harris and Sidney Levine of the Materials Research Support Division under the direction of Emil J. York, Chief, Materials Research Support Division, Military Technology Laboratory, USAMERDC.

CONTENTS

DEVELOPMENT OF A CONTINUOUS,

HARD-ANODIZED ALUMINUM SURFACE

I. INTRODUCTION

1. Statement of the Problem. The problem is to eliminate or minimize the effects of the crack system which is inherent in hard-anodized finishes on aluminum.

2. Background. The use of hard-anodized aluminum is precluded in many applications where extremely corrosive environments exist because of the crack system which extends from the coating surface to the base metal. The crack system originates because of differences between the coefficients of thermal expansion of the metal and the hard-anodic coating. Another disadvantage of hard-anodized aluminum is the lack of sufficient coverage (1)(2)* at sharp edges such as corners and threaded areas (Fig. 1).

Fig. 1. Photomicrograph of hard-anodized thread showing lack of coating at sharp edge. The photograph was taken in ordinary light at 250X. The white triangular area is the metallic aluminum.

*Numbers in parentheses refer to LITERATURE CITED, p. 8.

From the dearth of literature citations, it can be assumed that hard-anodized surfaces are not commonly used in severely corrosive environments.

II. EXPERIMENTAL PROCEDURE

3. Approaches to Problem. Corrosion resistance of hard-anodized aluminum alloys should be significantly increased by plugging the crack system so that there are no free pathways to the base metal.

a. A hard-anodized panel was immersed in hot water (at 200° F for 15 minutes) in an effort to plug the crack system by formation of hydrated oxide in the cracks. This technique is normally utilized to seal the pore system found in anodized aluminum. The "sealed" surface was tested for continuity with the acid $CuSO_4$ procedure (3).

b. It was also deemed practical to close the crack system by deposition of a conventional anodic coating between the metal and the hard coat. This coating when sealed should provide an effective barrier at points where the cracks are open to the base metal.

(1) Panels of 6061 aluminum having a 1-mil, hard-coat finish (4) were additionally anodized in a conventional, sulfuric acid anodizing bath. These panels were tested with acid $CuSO_4$ (3) for coating continuity.

(2) Hard-coated aluminum panels were cross sectioned, mounted, polished, and examined at 250X magnification under both ordinary and polarized light. The thicknesses of the coatings were measured.

(3) The Knoop microhardness number was determined on the anodized hard coat, on the hard coat, and on conventionally anodized finishes.

(4) The abrasion resistance and weight loss on abrasion were determined by means of the Taber Abrasor using CS-17 wheels under 1000-gram loads.

4. Analysis of Test Results. An analysis of test results follows.

a. The sealing procedure used on the conventional hard coat did not remove the discontinuities present in the original finish; the $CuSO_4$ test showed no decrease in discontinuity patterns (Fig. 2).

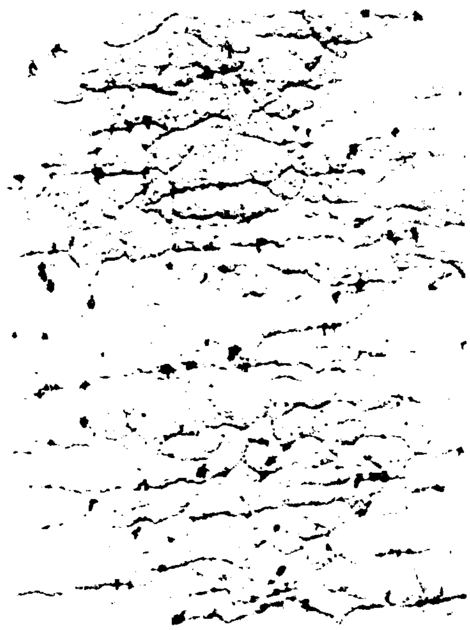

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Fig. 2. A 14X magnification of hard-anodized surface showing the results of copper sulfate continuity test. The crack system can be plainly seen. The dark spots are metallic copper deposited in the cracks. Each copper globule indicates a discontinuity.

b. The discontinuities were eliminated by the application of approximately ½ mil of conventional anodizing beneath the hard-coat surface.

(1) The hard coat panels which were given the additional anodized coating showed no discontinuities when subjected to the $CuSO_4$ test.

(2) Metallographic examination showed that the anodized, hard-coat layer was much thicker than the original hard coat (Fig. 3). When the anodized hard coat was photographed with polarized light it exhibited two distinct layers (Fig. 4). The thinner layer, which is lighter in color and is adjacent to the metal, is the secondary coating of conventional anodizing deposited below the original hard coat. Sharp edges, such as threaded areas which are thinly coated at best during the hard-coating process, showed a coating of conventional anodizing after the parts were given the secondary anodic treatment (Figs. 5 and 6).

Fig. 3. Photomicrograph of cross section of aluminum panel having anodized, hard-coat finish. The photograph was taken in ordinary light at 250X.

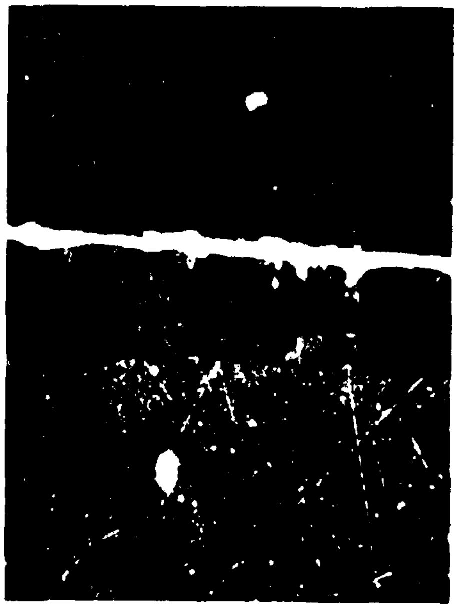

Fig. 4. Photomicrograph of cross section of panel having anodized, hard-coat finish. The photograph was taken in polarized light at 250X. The cross-hatched area at the bottom is the metallic aluminum. The two coatings can be seen as two, distinct layers across the middle of the picture. The secondary, conventional, anodized coating is the bottom layer next to the metallic aluminum.

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Fig. 5. Photomicrograph of a threaded area of an aluminum piece having an anodized, hard-coat finish. The picture shows the continuous coverage obtained at the sharp edge of the thread. The white area is metallic aluminum. The photograph was taken in ordinary light at 250X.

Fig. 6. Same area as in Fig. 5 but taken in polarized light.

(3) Table I gives the Knoop microhardness numbers of hard coat and anodized hard coat at various distances from the metal surface. Table II gives the same data for regular anodizing, both sealed and unsealed. All Knoop numbers given were obtained under a 25-gram load. The results of the microhardness tests show somewhat lower Knoop numbers for the anodized hard coat than for the regular hard coat. The anodized hard coat also shows a more significant variation in the magnitude of the Knoop numbers than does the regular hard coat. Regular anodizing gave higher Knoop values in the unsealed than in the sealed conditions. The conventional anodizing, both sealed and unsealed, gives Knoop values similar to those obtained for hard-anodized coatings. Lower Knoop values were obtained at greater distances from the metallic surface in all cases.

Table I. Knoop Hardness Tests of Hard Coat and Anodized Hard Coat

Distance from Metal-Coating Interface	Knoop Hardness (K_{25})	
	Hard Coat	Anodized Hard Coat
Near metal	628.0	484.3
Near outer surface	607.5	211.6

Table II. Knoop Hardness Tests of Conventional Anodizing

Distance from Metal-Coating Interface	Knoop Hardness (K_{25})	
	Unsealed	Sealed
Near metal	807.5	710.0
Near surface	737.0	617.5

c. Abrasion Tests. The number of cycles to failure and the weight loss to failure are given in Table III for hard coat, anodized hard coat, and conventional anodizing. Failure was taken as the first visual sign of a definite break through to the base metal. The results of the abrasion tests indicate no significant differences in rubbing abrasion resistance between hard-coat and anodized hard-coat finishes.

Table III. Abrasion Tests

Coating	Cycles to Failure	Weight Loss to Failure (mg)
Anodizing	47,000	45
Hard Coat	207,000	194
Anodized Hard Coat	209,000	227

III. CONCLUSIONS

5. Conclusions. It is concluded that:

a. A secondary coating of conventional anodizing can be deposited between the hard-anodized finish and the metallic aluminum on previously hard-coated aluminum.

b. The presence of the secondary coating significantly increases the continuity of the hard-anodized finish.

c. The presence of the secondary coating in no way impairs the resistance of the hard-anodized finish to rubbing abrasion.

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